TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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# THE EFFECTS OF PARTIAL-SPAN SLOTTED FLAPS ON THE AERODYNAMIC CHARACTERISTICS OF A RECTANGULAR AND A TAPERED N.A.C.A. 23012 WING

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Washington
July 1939

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## SUMMARY

An investigation was made in the N.A.C.A. 7- by 10-foot wind tunnel to determine the aerodynamic characteristics of tapered and rectangular wings with partial-span slotted flaps. Two N.A.C.A. 23012 airfoils equipped with center-section and tip-section flaps were tested.

The results showed that the changes in lift and drag due to changes in flap span for both rectangular and tapered wings having partial-span slotted flaps were similar to those for corresponding wings having partial-span split or plain flaps. For the two wings tested, higher values of maximum lift were obtained with center-section slotted flaps than with tip-section slotted flaps of the same size. The highest values of lift-drag ratio at maximum lift for the rectangular wing were obtained with center-section flaps and, for the tapered wing, with tip-section flaps. Center-section flaps on the tapered wing gave higher values of drag at maximum lift than tip-section flaps; no great difference in drag at maximum lift was apparent for either center-section or tip-section slotted flaps on the rectangular wing.

## INTRODUCTION

Wing flaps are used on many present-day airplanes as a means of increasing the speed range. Partial-span flaps are employed in nearly all cases because part of the trailing edge is usually required for lateral control.

Investigations have been made to determine the effects on rectangular and tapered wings of partial-span split and plain flaps. The results are reported in references 1, 2, and 3. The present investigation deals with similar arrangements of slotted flaps.

## APPARATUS AND TESTS

Models.- The models used in these tests were built of laminated mahogany to the N.A.C.A. 23012 profile, each model having a span of 60 inches and an aspect ratio of 6. One wing is rectangular in plan form (fig. 1) and the other is tapered 5:1 (fig. 2). For the tapered wing, the N.A.C.A. 23012 profile was used at all sections along the span and the maximum ordinates of all sections were in a horizontal plane on the upper surface.

The flap used is the N.A.C.A. slotted flap 2-h described in reference 4. It was cut into sections to form 10 flaps of equal span. The flap angle was measured in a plane parallel to the plane of symmetry.

Wind tunnel.- The models were mounted on the standard force-test tripod in the N.A.C.A. 7- by 10-foot closed-throat wind tunnel, which is described in reference 4.

Tests.- The tests were made at a dynamic pressure of 16.37 pounds per square foot, corresponding to an air speed of about 80 miles per hour at standard sea-level conditions and to an average test Reynolds Number of 609,000.

Tests were made with center-section and tip-section flaps 20, 40, 60, and 80 percent of the span deflected 40° and with full-span flaps neutral and deflected 40°. A metal strip on the wing upper surface was used to seal the exit of the slot of the undeflected part of the flap. The angles of attack covered a range from -14° to 20°, which included zero and maximum lifts.

## RESULTS AND DISCUSSION

### Coefficients

The results are given in the form of absolute coefficients of lift, drag, and pitching moment:

$$C_L = \frac{L}{qS}$$

$$C_D = \frac{D}{qS}$$

$$C_{m_{(a.c.)_o}} = \frac{M_{(a.c.)_o}}{qcS}$$

where

$L$ is wing lift.

$D$, wing drag.

$M_{(a.c.)_o}$, pitching moment about aerodynamic center of plain wing.

$q$, dynamic pressure.

$S$, wing area.

$c$, mean wing chord.

and

$b$ is wing span.

The data have been corrected for the effects of the wind-tunnel jet boundaries to aspect ratio 6 in free air.

## Rectangular Wing

Curves of lift, drag, and pitching-moment coefficients for the rectangular wing with center-section flaps are given in figure 3 and similar curves for the wing with tip-section flaps are given in figure 4. The values of $C_L$, $C_D$, and $C_{m_{(a.c.)_o}}$ increase with an increase in flap span for both the center-section and the tip-section flaps. In general, at a given angle of attack, higher values of $C_L$ and lower values of $C_D$ are obtained with center-section flaps than with tip-section flaps of equal span. The angle for maximum lift for the wing with tip-section flaps decreases with increase in flap span in much the same manner as that for plain flaps (reference 1). An exception is the wing with the full-span flap, which stalls at about the same angle of attack as the plain wing. No definite change in the angle for maximum lift with change in flap span was apparent for the wing with center-section flaps.

Greater increments of lift are obtained with slotted flaps than with either split or plain flaps of the same span (references 1 to 3).

The wing with the center-section flaps has higher values of $C_{L_{max}}$ and L/D at $C_{L_{max}}$ than the wing with tip-section flaps of equal span (fig. 5). The values of $C_D$ at $C_{L_{max}}$ are not greatly different for either tip-section or center-section flaps, although slightly lower values of $C_D$ are obtained with center-section flaps for all flap spans except 0.80b.

## Tapered Wing

Curves of lift, drag, and pitching-moment coefficients for the tapered wing with partial-span slotted flaps are given in figures 6 and 7. It is seen that the inboard sections of the flaps give larger increments of lift and drag because of the greater wing area affected. The angle for maximum lift decreases with an increase in flap span and occurs at about the same angle for center-section or tip-section flaps of equal span.

The wing with center-section flaps has higher values of $C_{L_{max}}$ and $C_D$ at $C_{L_{max}}$ and lower values of L/D at $C_{L_{max}}$ than the wing with tip-section flaps of the same span (fig. 8). Values of L/D at $C_{L_{max}}$ for the wing with center-section flaps change little with an increase in flap span beyond 0.40b.

## CONCLUDING REMARKS

The changes in lift and drag due to changes in flap span for both rectangular and tapered wings having partial-span slotted flaps were similar to those for corresponding wings having partial-span split or plain flaps, but greater increments of lift were obtained with the slotted flaps.

Higher values of maximum lift and lift-drag ratio at maximum lift were obtained for the rectangular wing with center-section flaps than with tip-section flaps of equal span; whereas, for the tapered wing, the maximum lift and the drag at maximum lift were greater and the lift-drag ratio was less with center-section flaps than with tip-section flaps of equal span.

It should be borne in mind that the point along the span at which the stall begins may have an appreciable effect on the value of the maximum lift obtained in flight. If the tips stall first, any further increase in angle of attack is limited, although it may be several degrees below the angle at which maximum lift is obtained in a wind tunnel. Consequently, some of the values of the maximum lift coefficient given for the tapered wing and for the rectangular wing with center-section flaps may be somewhat higher than those attainable in flight.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., April 25, 1939.

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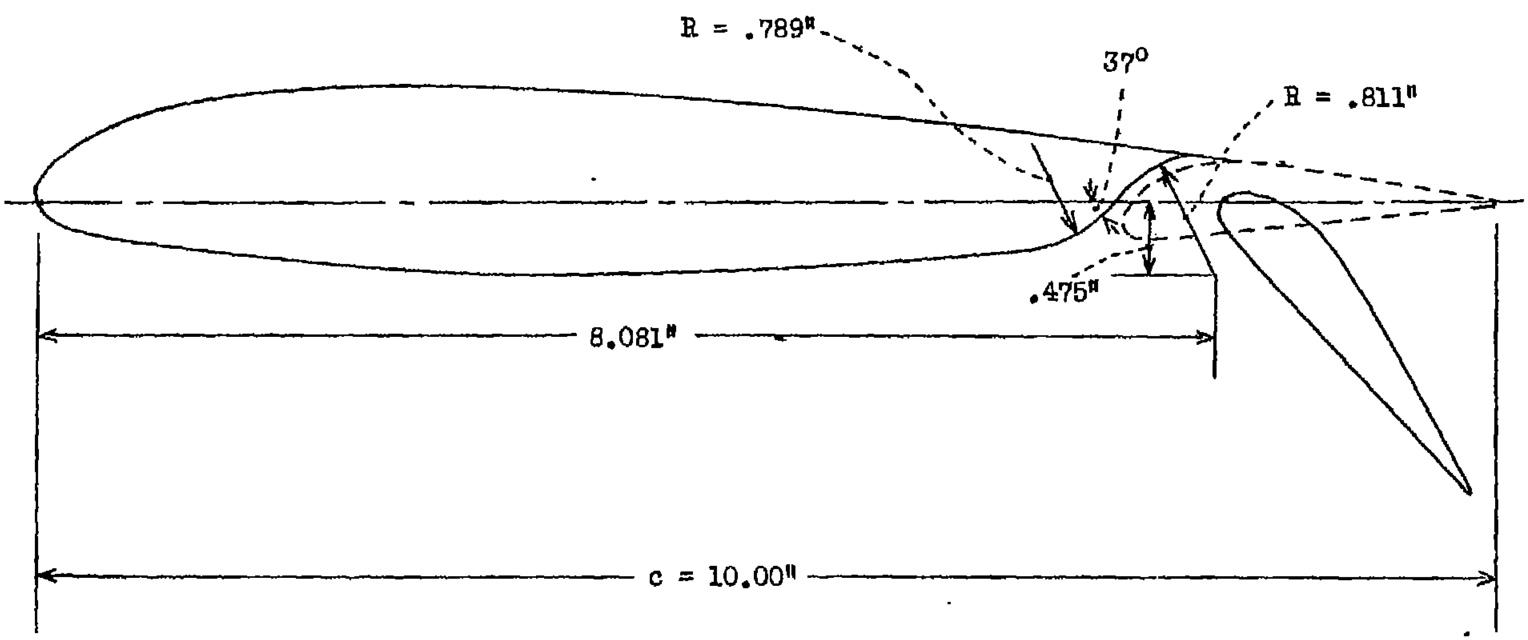


Figure 1.- N.A.C.A. slotted flap on the rectangular N.A.C.A. 23012 wing.

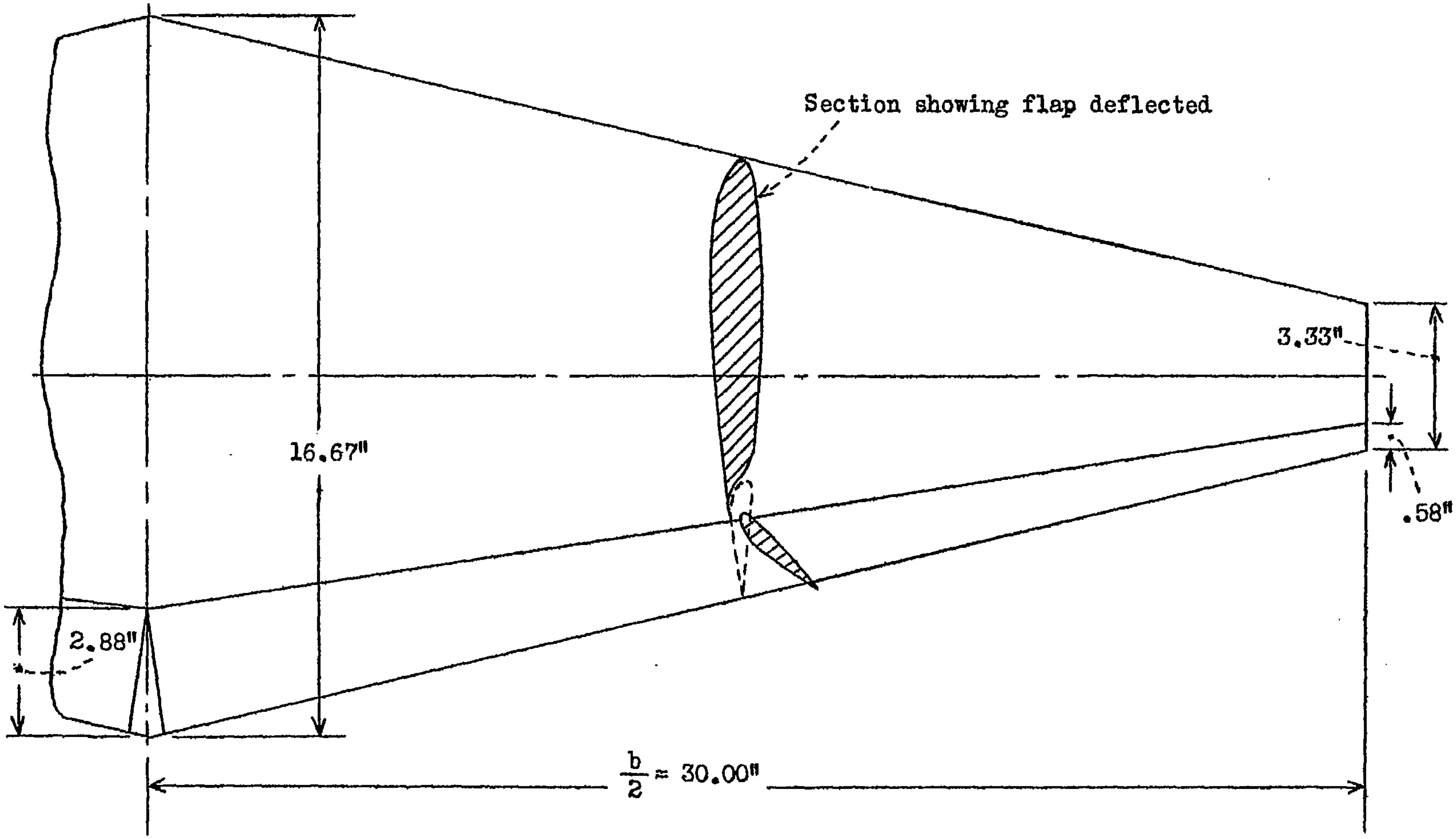


Figure 2.- N.A.C.A. slotted flap on the 5:1 tapered N.A.C.A. 23012 wing.

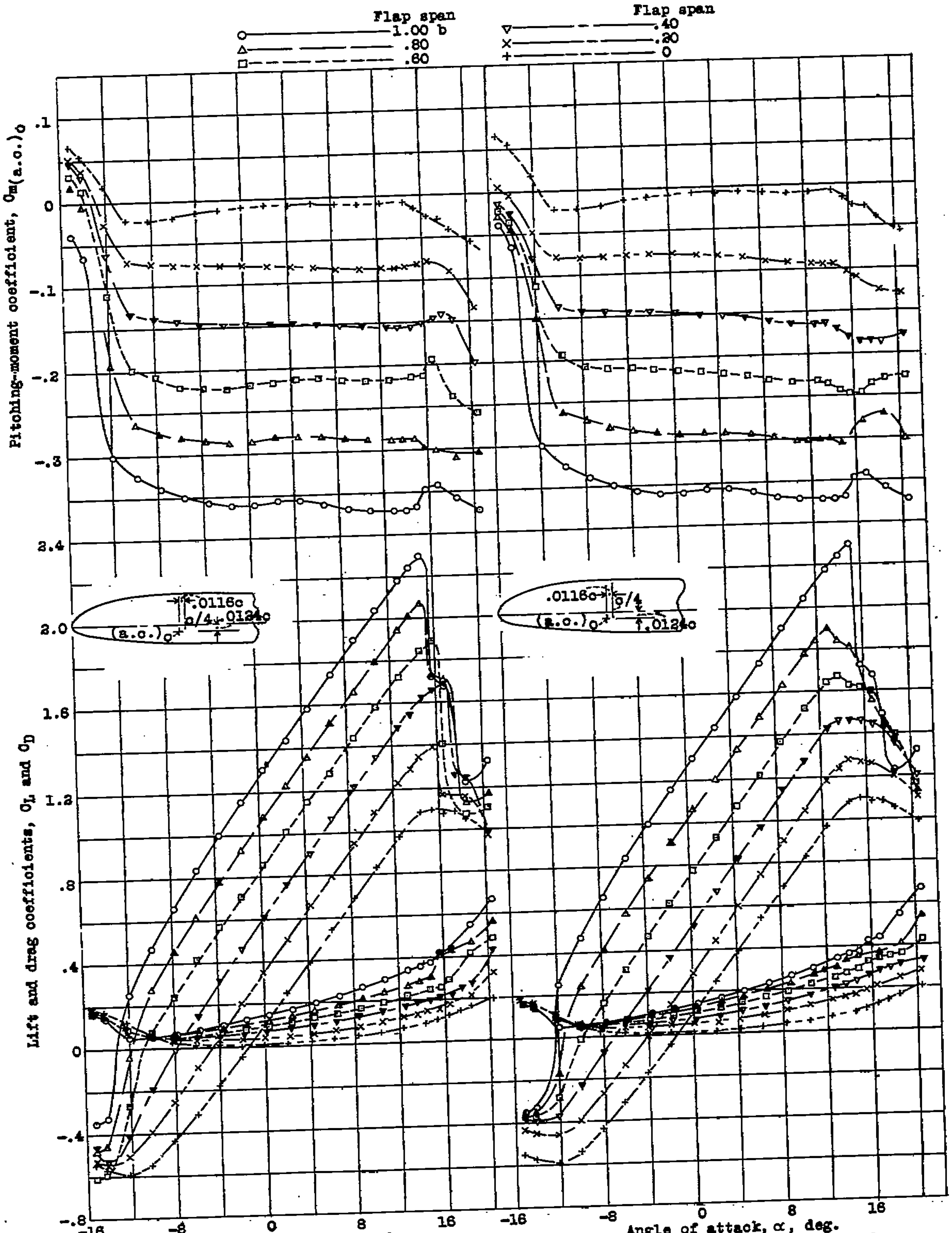


Figure 3.- Variation of lift, drag, and pitching-moment coefficients with angle of attack. Center-section slotted flaps on the rectangular N.A.C.A. 23012 wing. $\delta_f$ = 40°.

Figure 4.- Variation of lift, drag, and pitching-moment coefficients with angle of attack. Tip-section slotted flaps on the rectangular N.A.C.A. 23012 wing. $\delta_f$ = 40°.

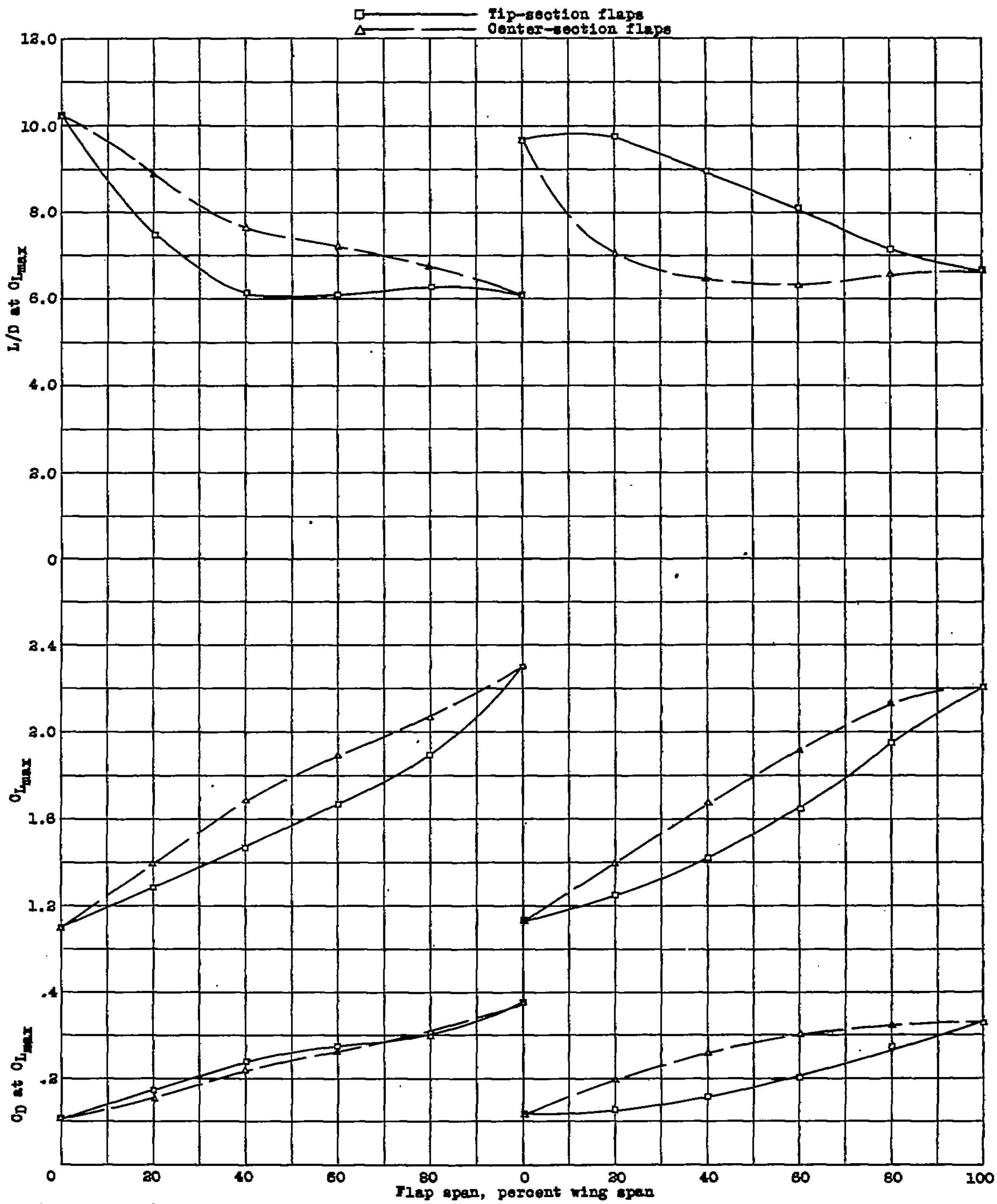


Figure 5.- Effect of flap length on $C_{L_{max}}$, on $C_D$ at $C_{L_{max}}$, and on L/D at $C_{L_{max}}$. Rectangular N.A.C.A. 23012 wing. $\delta_f = 40°$.

Figure 8.- Effect of flap length on $C_{L_{max}}$, on $C_D$ at $C_{L_{max}}$, and on L/D at $C_{L_{max}}$. 5:1 tapered N.A.C.A. 23012 wing. $\delta_f = 40°$.

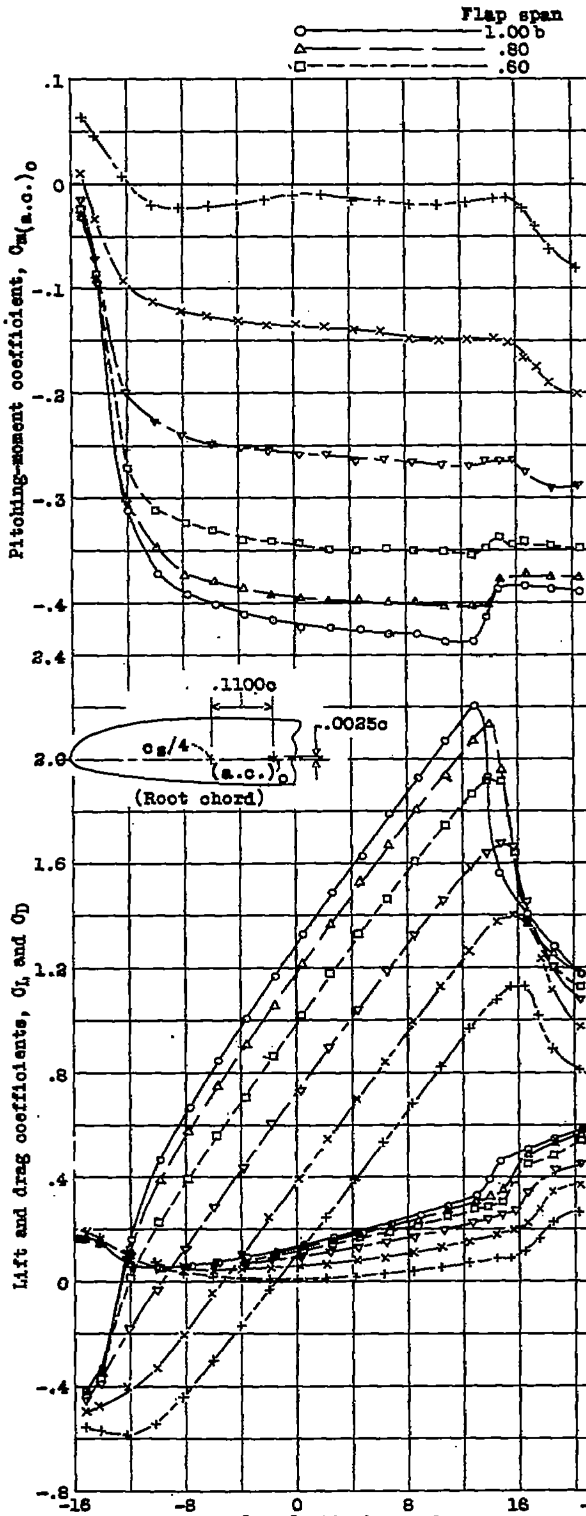


Figure 6.- Variation of lift, drag, and pitching-moment coefficients with angle of attack. Center-section slotted flaps on the 5:1 tapered N.A.C.A. 23012 wing. $\delta_f = 40^\circ$

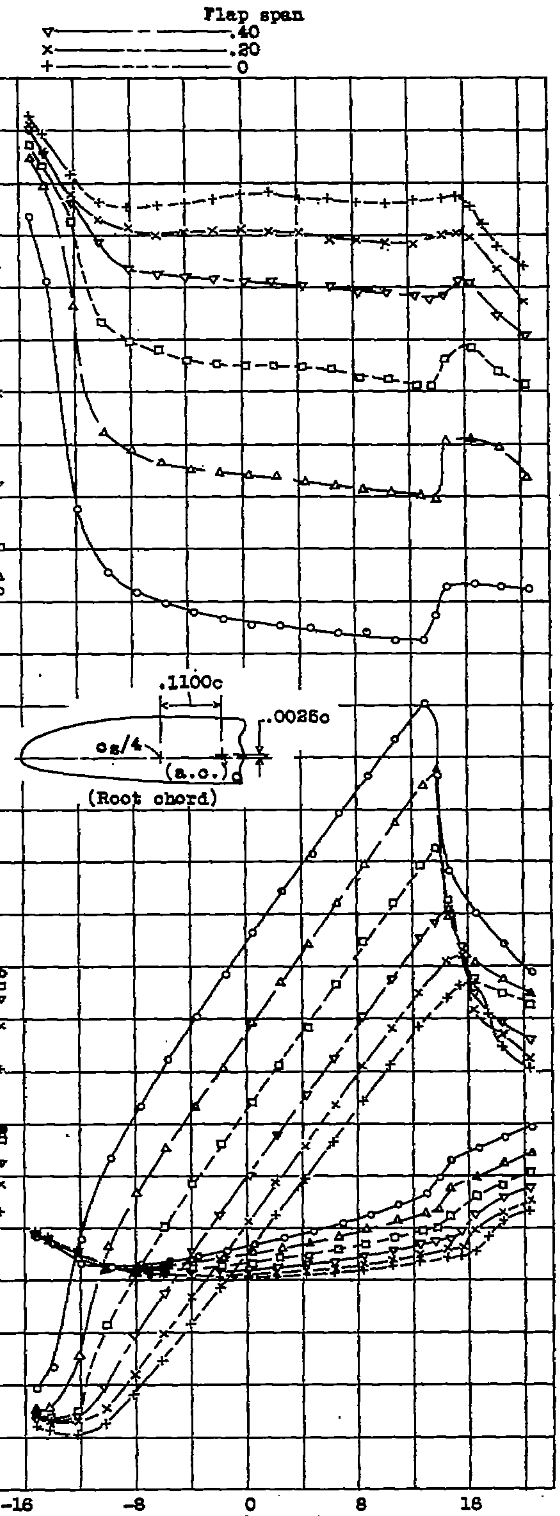


Figure 7.- Variation of lift, drag, and pitching-moment coefficients with angle of attack. Tip-section slotted flaps on the 5:1 tapered N.A.C.A. 23012 wing. $\delta_f = 40^\circ$